

REPORT DOCUMENTATION PAGE

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MEMORANDUM FOR PRS (In-House Publication)

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01 May 2003

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-VG-2003-117**
C.T. Liu (AFRL/PRSM) et al., "Multi-Scale Strain Measurements of a Polymeric Material"

5642

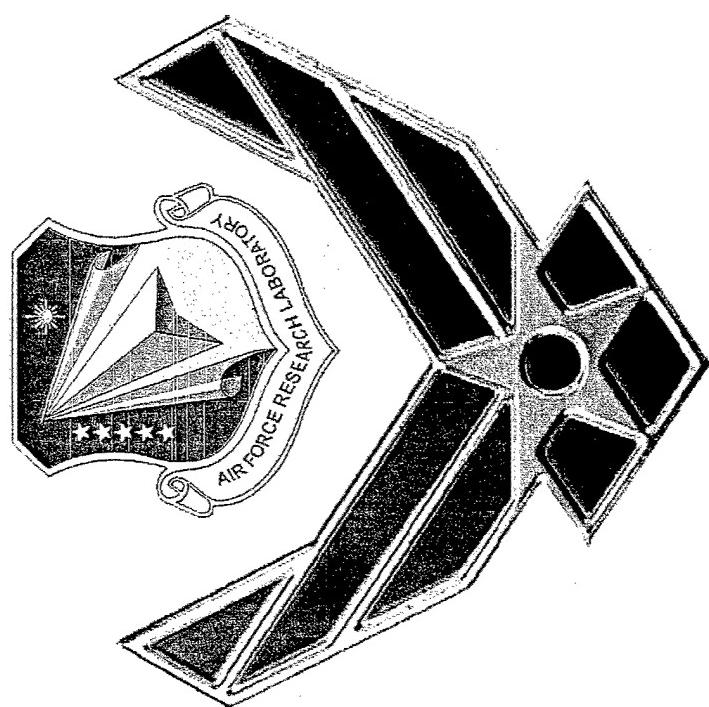
2003 SEM Conf: Exprmtl & Appl Mechanics
(Charlotte, NC, 2-4 June 2003) (Deadline: 25 May 2003)

(Statement A)

Multi-Scale Strain Measurements of a Polymeric Material

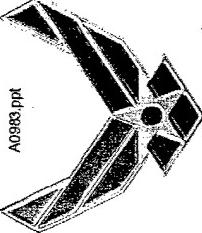
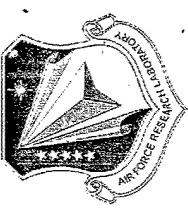
C. T. Liu
AFRL/PRSM
10 E. Saturn Blvd.
Edwards AFB CA 93524-7680, U.S.A

Fu-Pen Chiang
Department of Mechanical Engineering
State University of New York
Stony Brook NY 11790

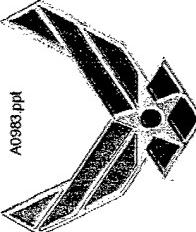
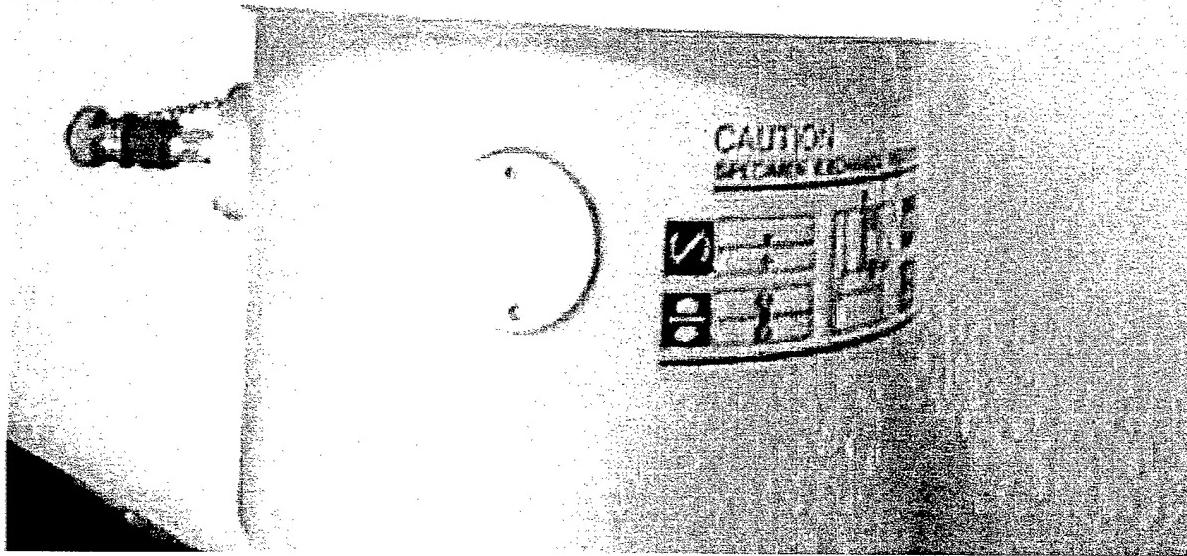
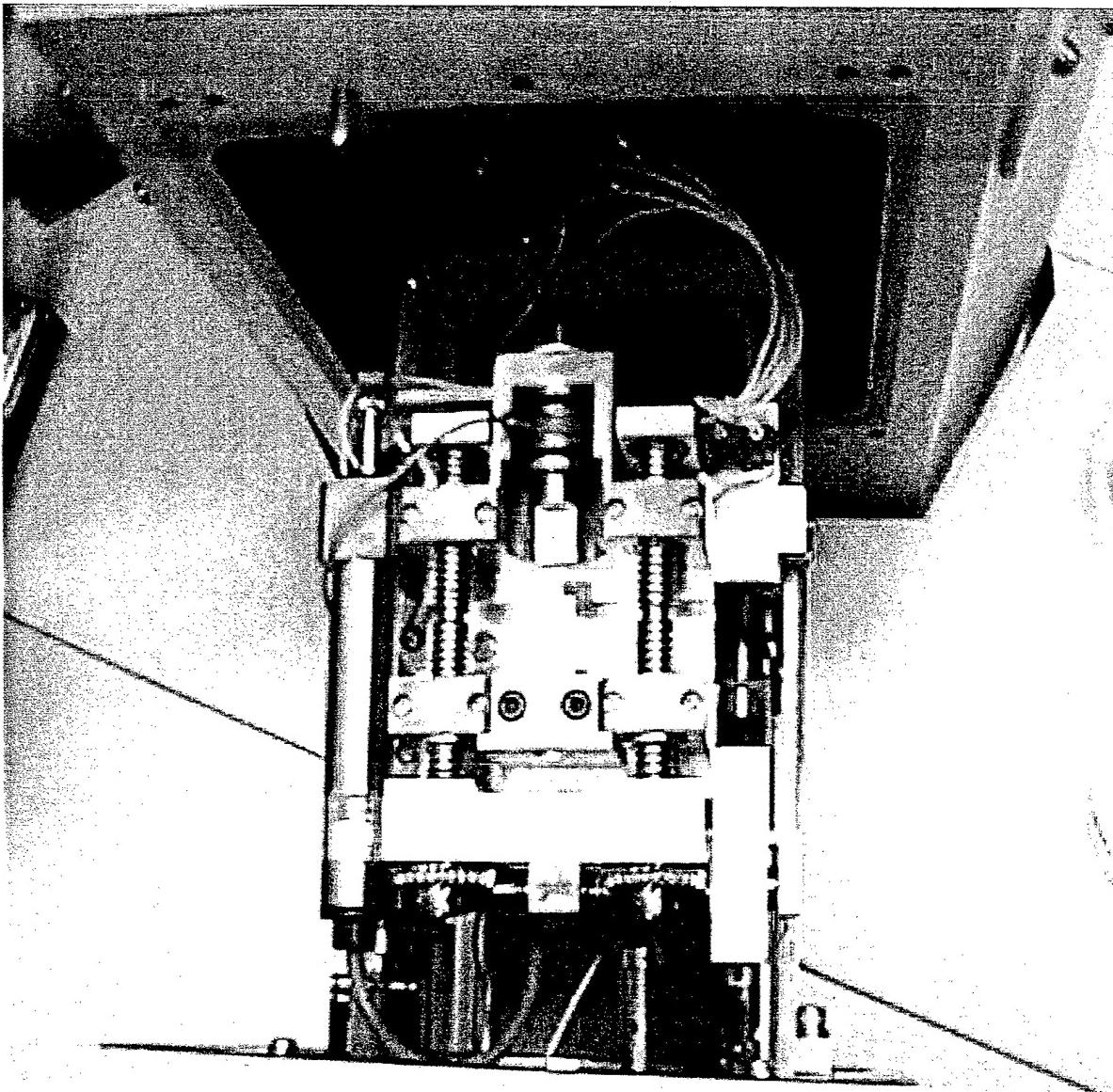


Objectives

- Determine the Displacement and Strain Fields in a Polymeric Material
- Investigate the Local Damage Mechanisms and Failure Behavior near the Crack Tip

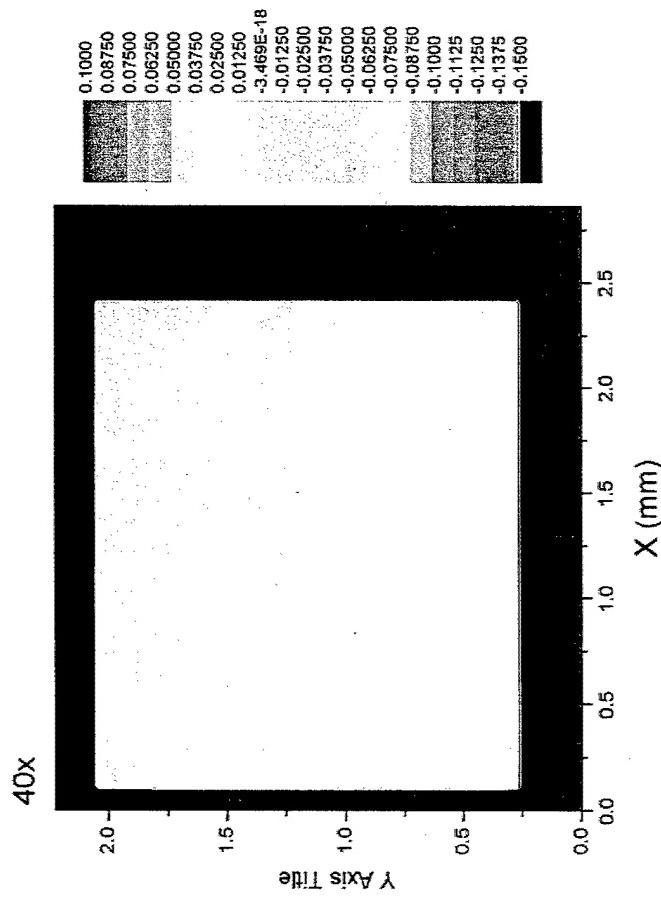
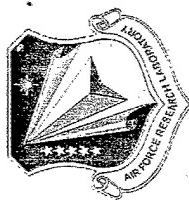


Testing Set-Up

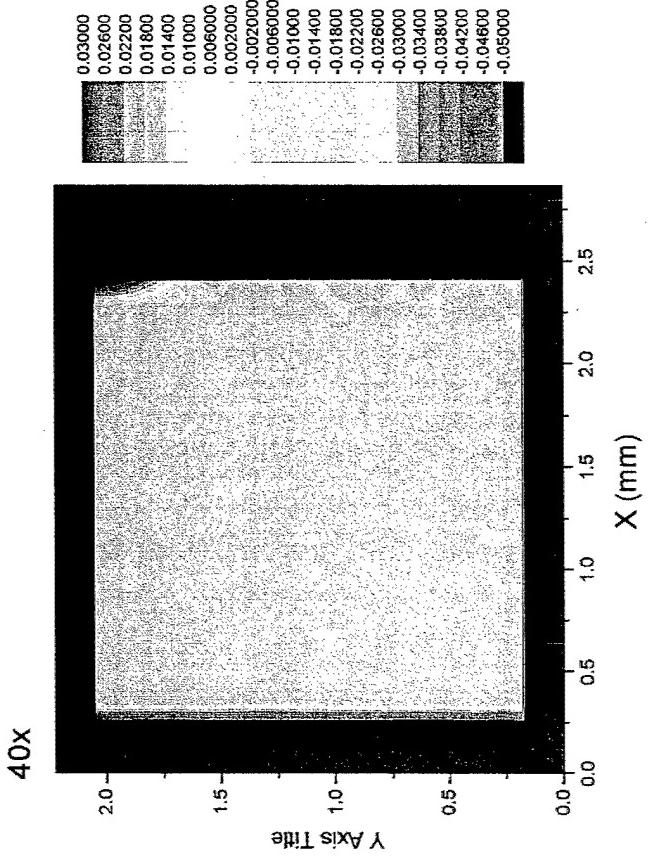


Strain Distributions (2.5mm x 2.0mm)

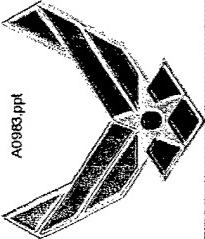
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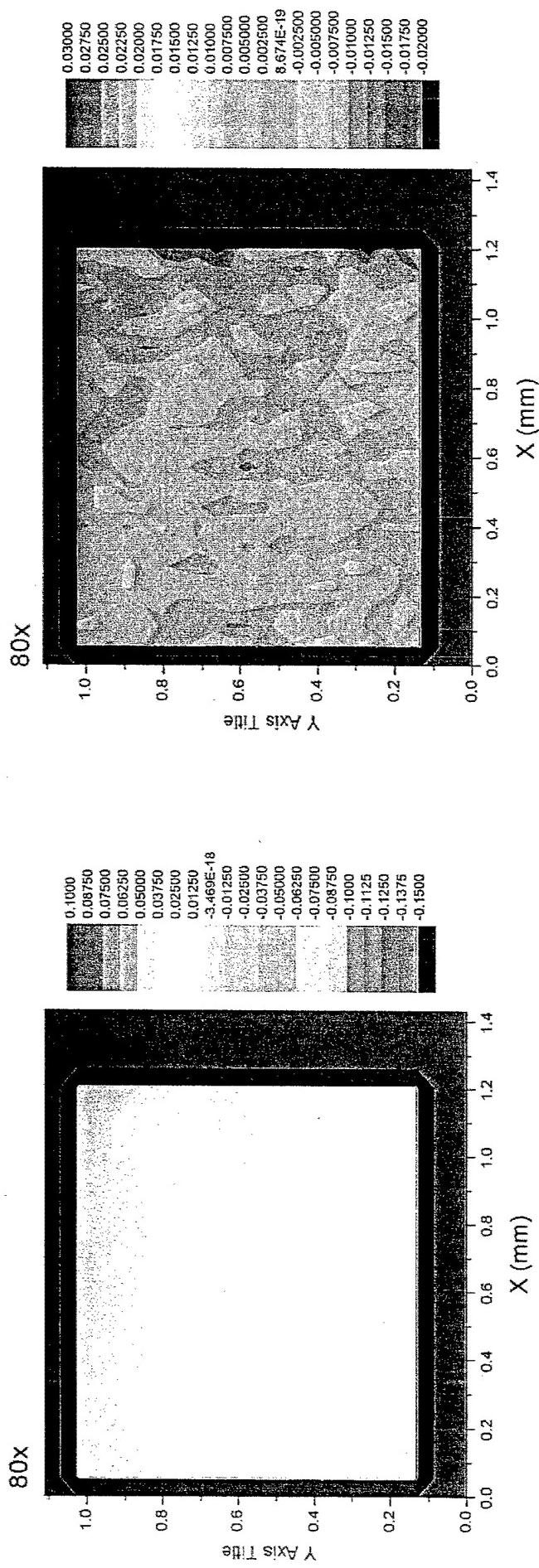
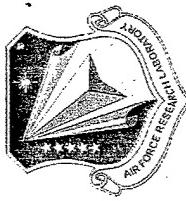
ϵ_{yy} field, Load = 52 grams



ϵ_{xx} field, Load = 52 grams



Strain Distributions (1.2mm x 1.0mm)



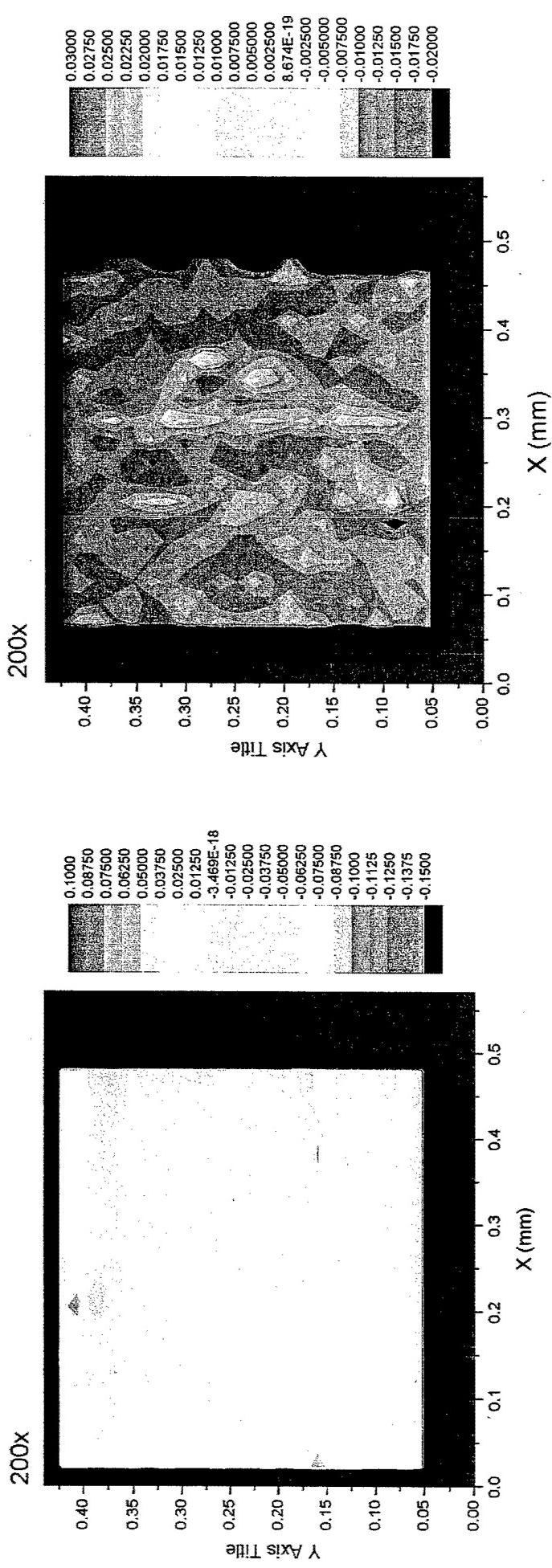
ϵ_{yy} field, Load = 41 grams

ϵ_{xx} field, Load = 41 grams

Strain Distributions (0.5mm x 0.45mm)

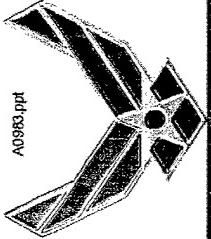


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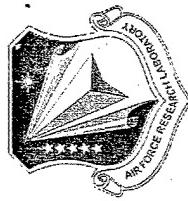


ϵ_{yy} field, Load = 47 grams

ϵ_{xx} field, Load = 47 grams



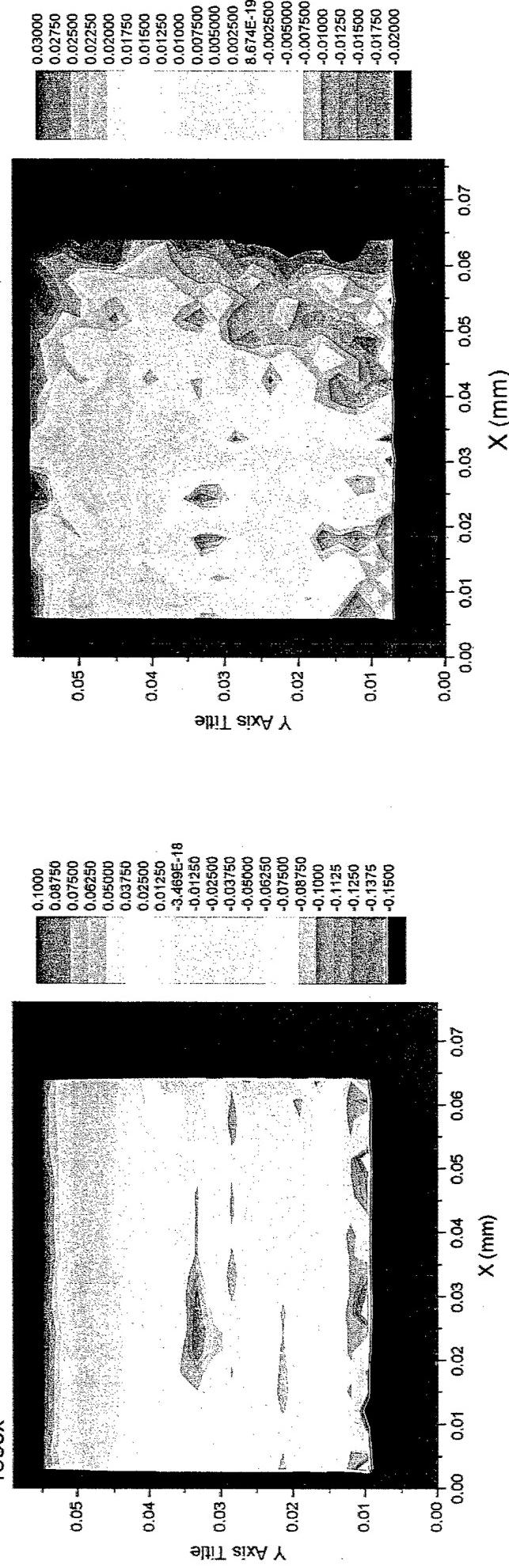
Strain Distributions (0.065mm x 0.055mm)



1500x

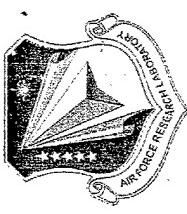
1500x

1500x

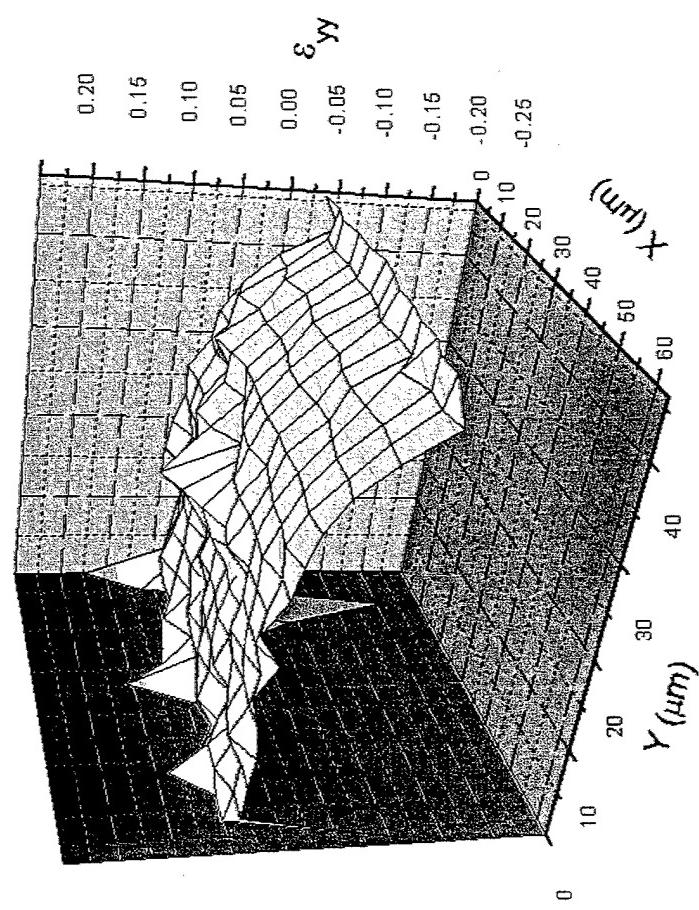


ϵ_{xx} field, Load = 49 grams

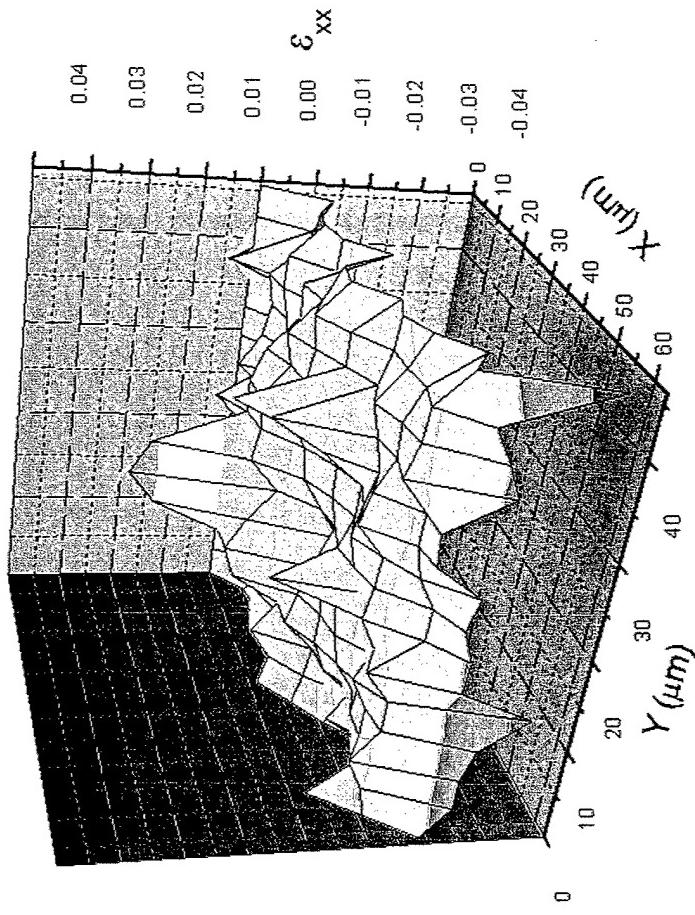
ϵ_{yy} field, Load = 49 grams



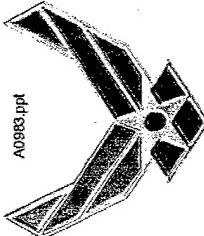
Strain Distribution (0.065mm x 0.055mm)



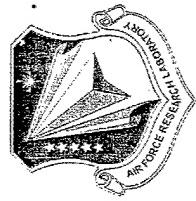
ϵ_{yy} field (3-D), Load = 49 grams



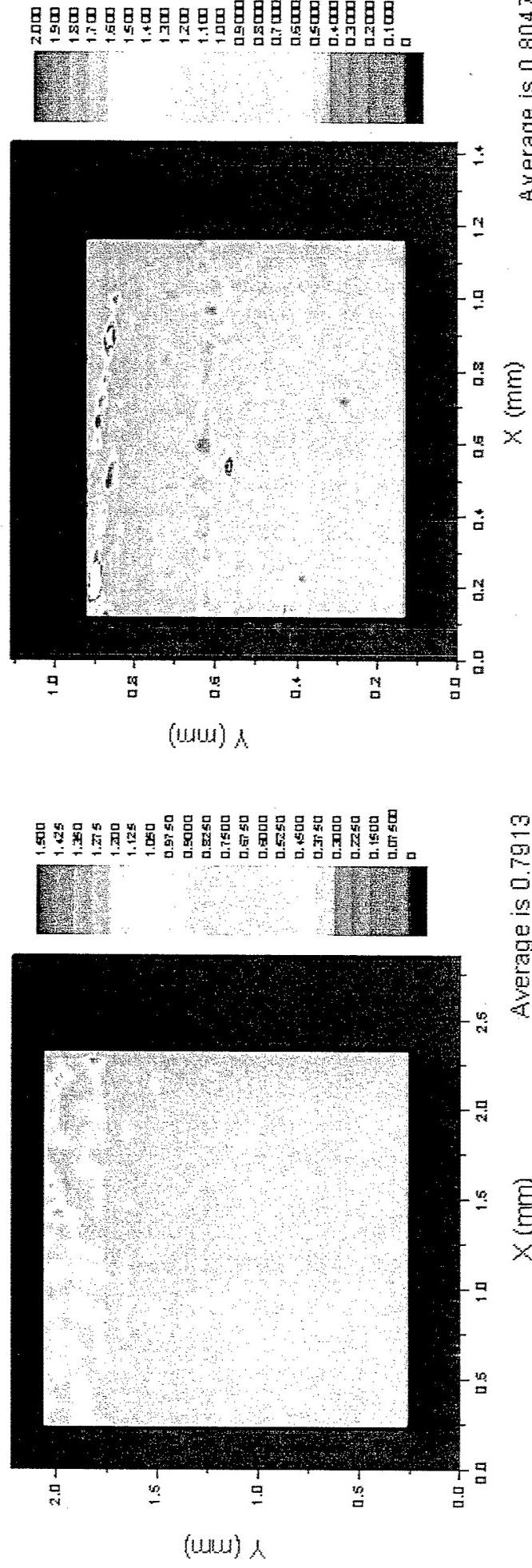
ϵ_{xx} field (3-D), Load = 49 grams



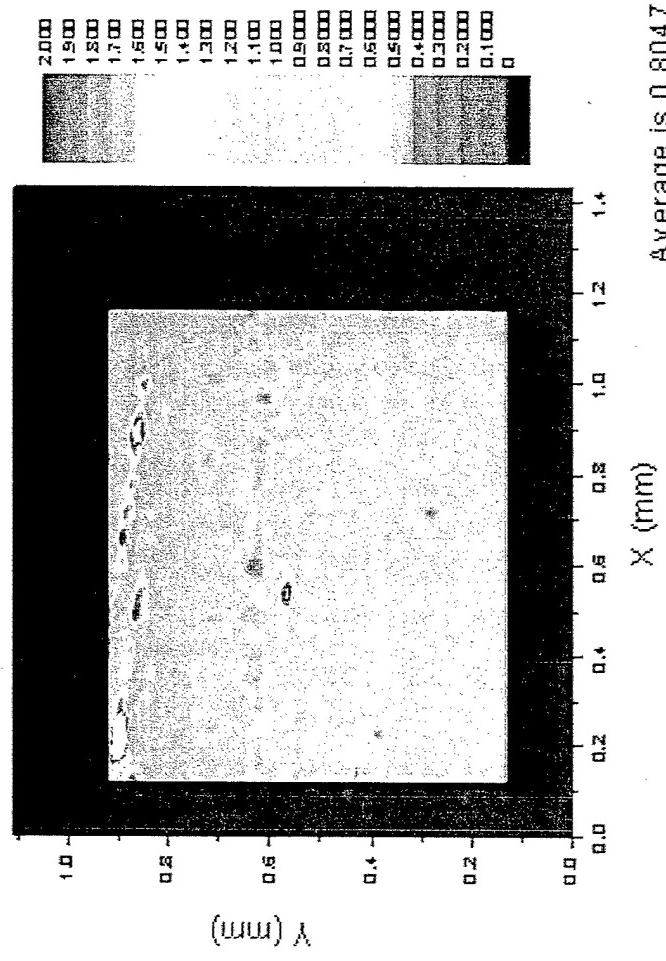
Strain Ratio ($-\epsilon_{xx}/\epsilon_{yy}$) Distributions at Different Magnifications



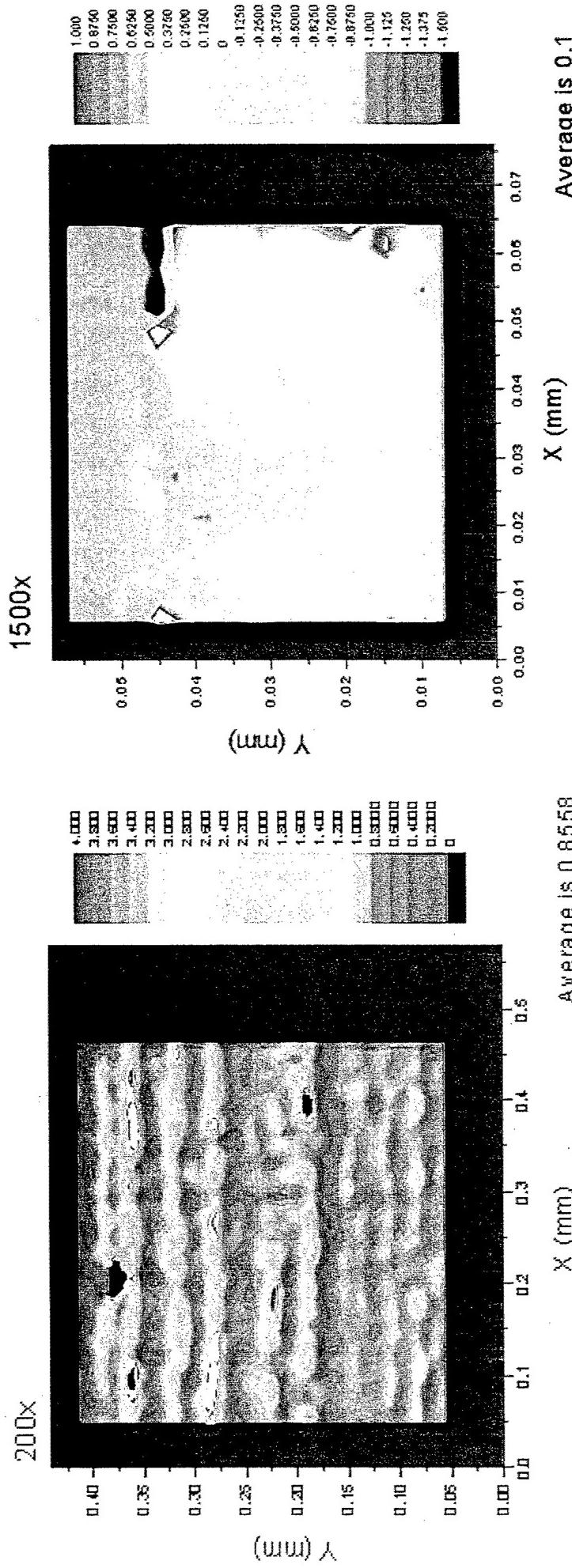
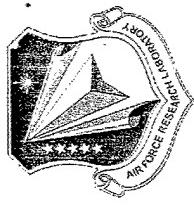
40x "Poisson Ratio" distribution



80x

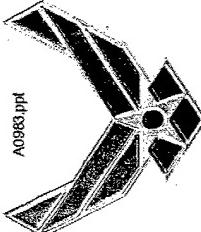


Strain Ratio ($-\epsilon_{xx}/\epsilon_{yy}$) Distributions at Different Magnifications

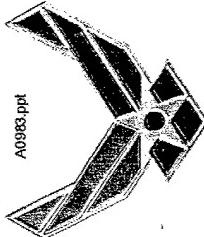




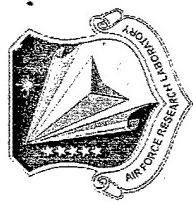
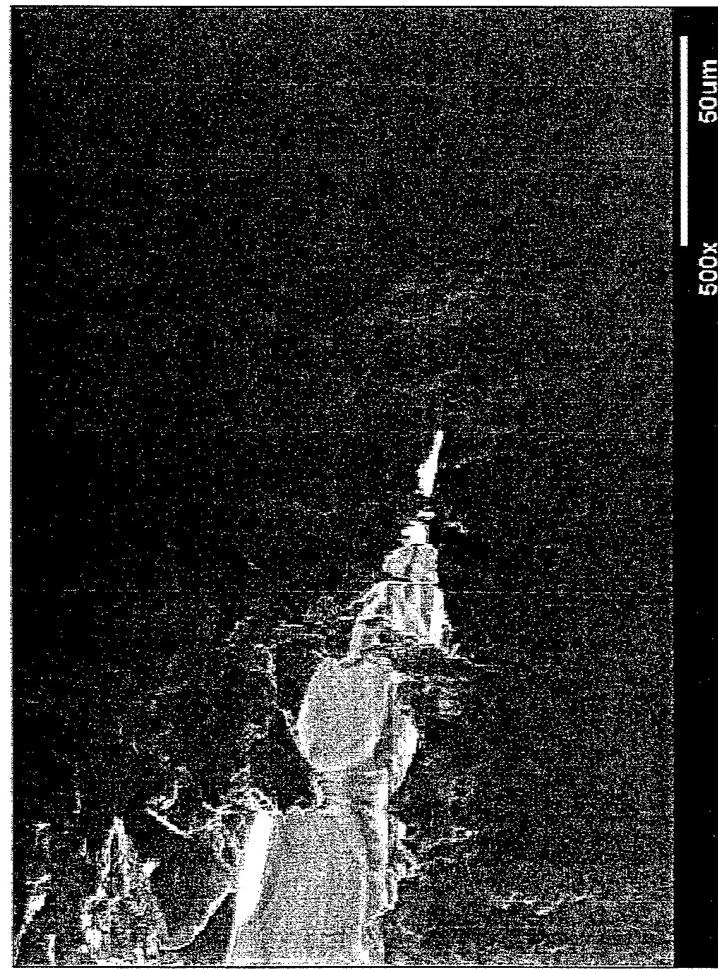
Side View of Crack Tip at 150x & 400x



Side View of Crack Tip at 500X & 1000X

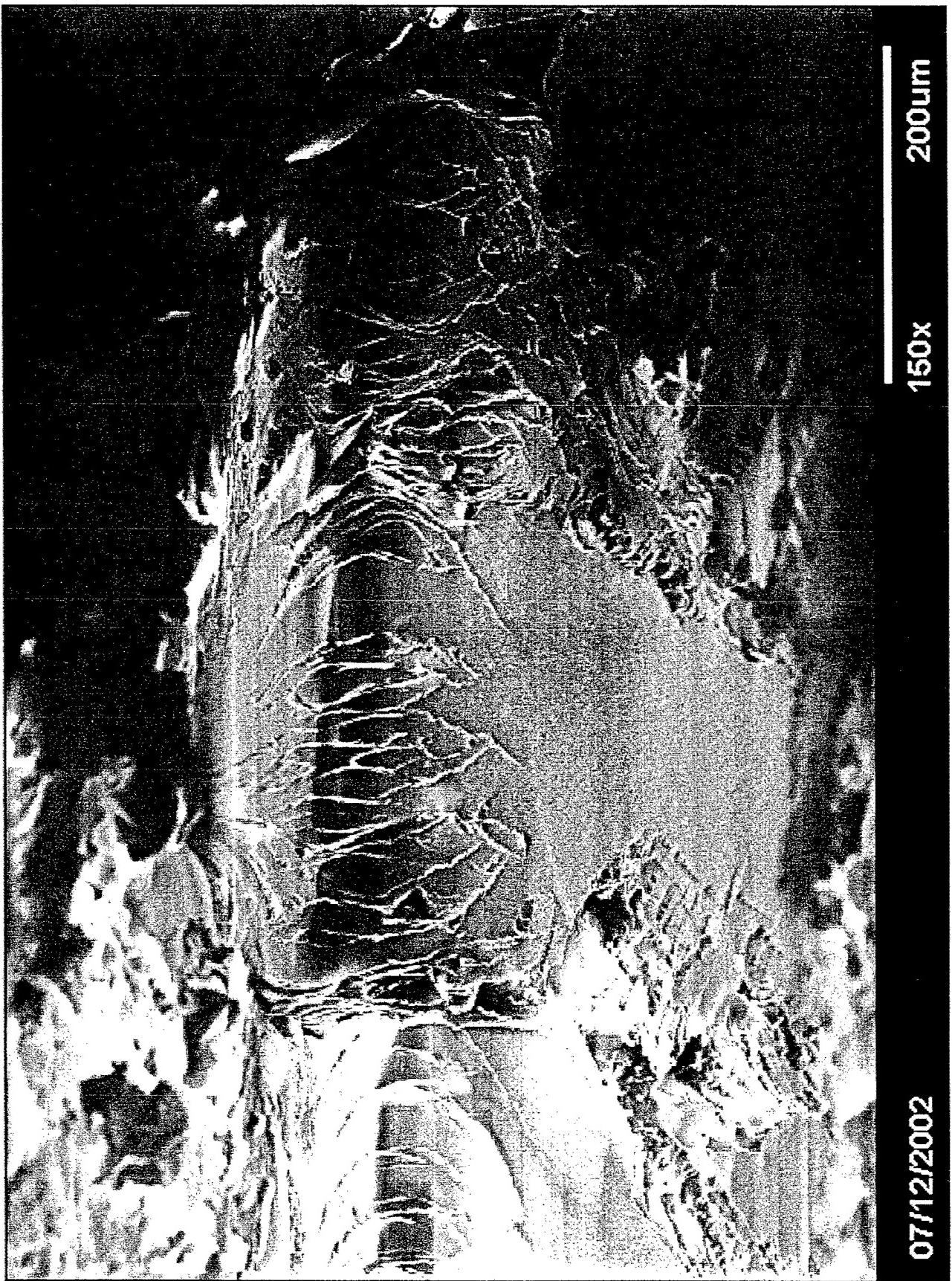


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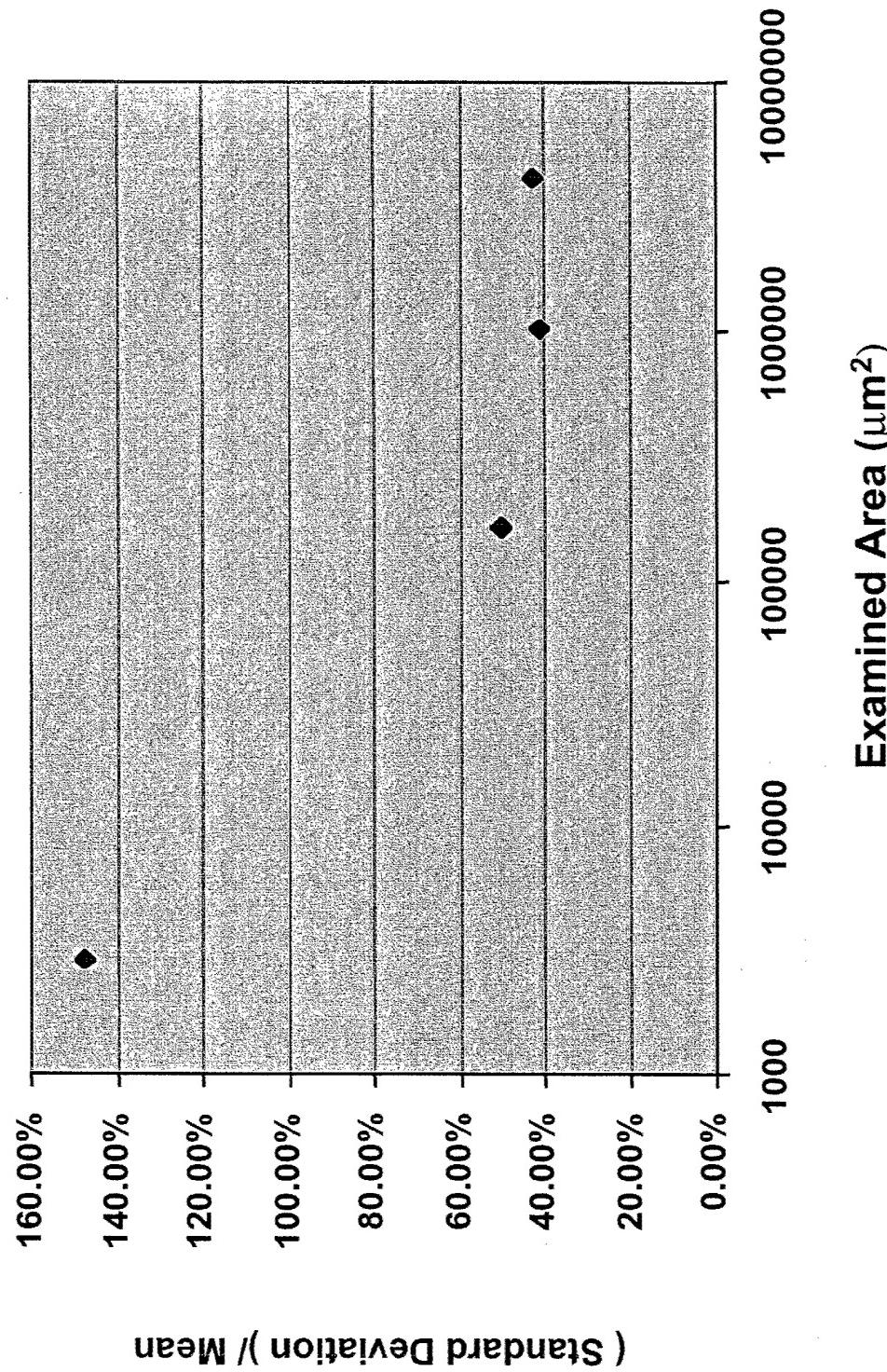
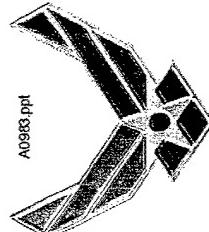
Crack Tip Top View

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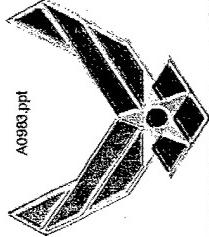


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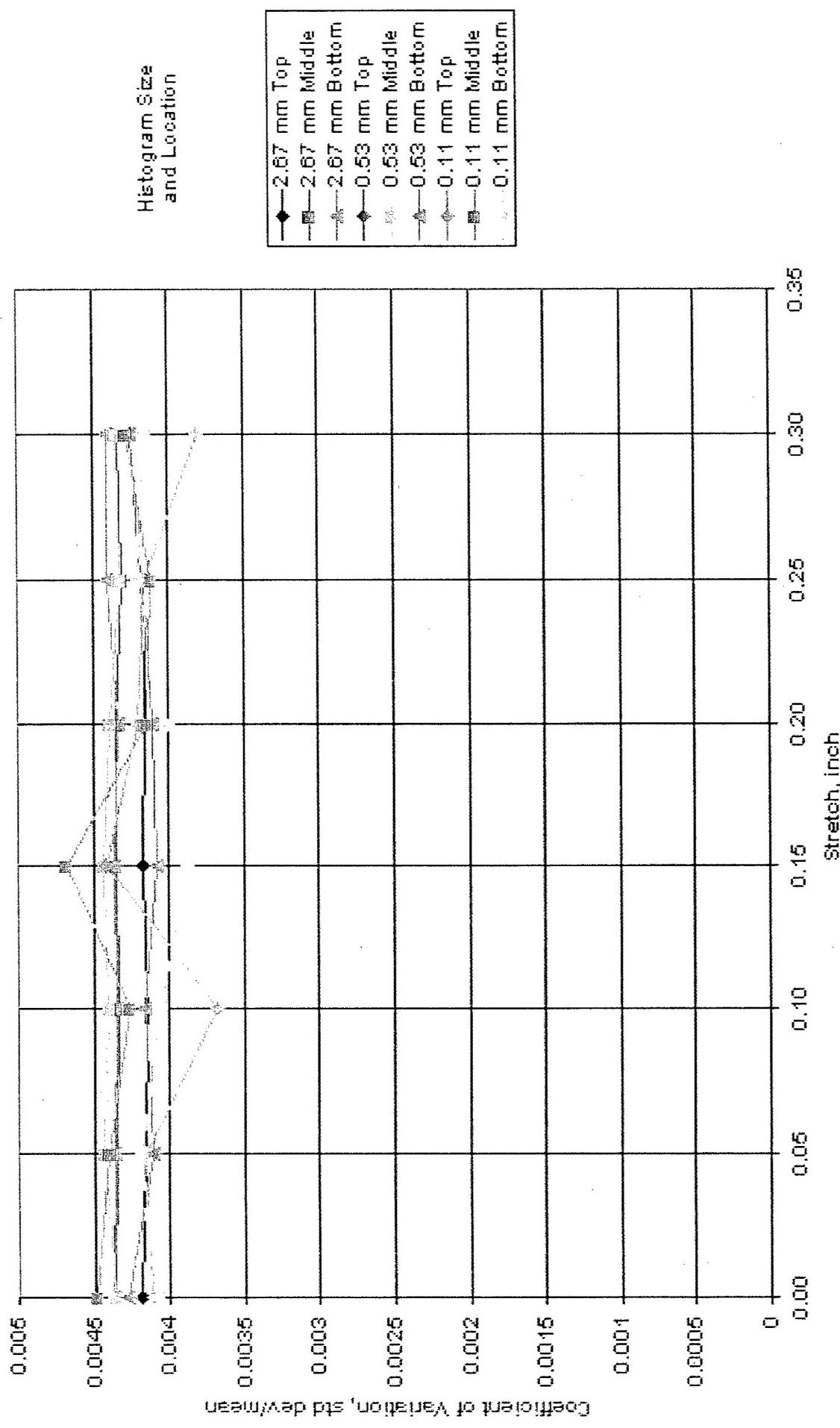
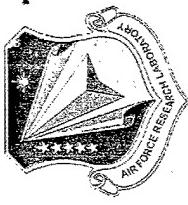
Standard Deviation / Mean of ϵ_{xx} Vs. Examined Area



Coefficient of Variation of X-Ray Intensity



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Conclusions

- The strain distributions vary with the size of the area, A, in which the data were analyzed.
- When the size of A is smaller or equal to $1.5 \text{ mm} \times 1.5 \text{ mm}$.the nonuniformity of the strain distributions is increased. Especially, when the size of A is equal to $0.065 \text{ mm} \times 0.055 \text{ mm}$, both tensile and compressive strain fields exist in the small area
- The representative area, which is defined as an area in which the material's microstructure has no significant effect on the strain distribution, of the material considered is $1.5 \text{ mm} \times 1.5 \text{ mm}$.
- A highly damaged region of 20-50 micron long is developed at the crack tip.
- The crack growth mechanism involves voids formation ahead of the crack tip and the coalescence of the main crack tip with the void.